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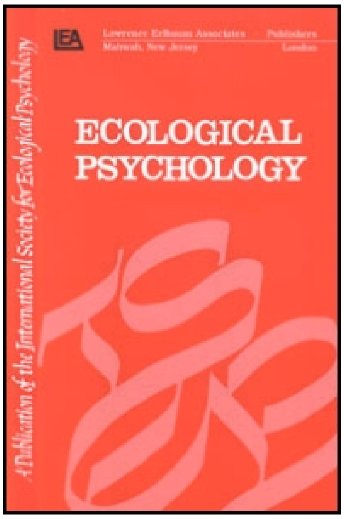

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The Role of Anxiety in Perceiving and Realizing Affordances

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Three experiments were conducted to examine the role of anxiety in perceiving and realizing affordances in wall climbing. Identical traverses were situated high and low on a climbing wall to manipulate anxiety. In Experiment 1, participants judged their maximal overhead reachability and performed maximal reaches on the climbing wall. Anxiety was found to reduce both perceived and actual maximal reaching height. In Experiment 2, participants climbed from right to left and back again on the high and low traverses, which now entailed an abundance of holds. Consistent with the reduction of perceived and actual maximal reaching height found in Experiment 1, anxiety led to the use of more holds. Finally, in Experiment 3, points of light were sequentially projected around the participants while they were climbing to measure attention. As participants detected fewer lights in the high-anxiety condition, it was concluded that anxiety narrowed attention. In general, the results underscored that the actor's emotional state plays an important role in perceiving and realizing affordances and that the perception of affordances changes as the accompanying action capabilities change.

When anxious, it is often difficult—quite literally—to keep things in perspective, as is illustrated by anecdotal evidence. In an attempt to conquer K2 (Karakorum Peak No. 2 in Pakistan; 8,616 m high), mountaineer Ronald Naar was faced with a small wall of ice. Usually, he would not have had any difficulty overcoming such an obstacle, but on this particular occasion—according to his own report—he suddenly froze with fear, and the ice wall seemed to him more problematical to surmount than the most horrifying key passages he had seen and conquered in his long

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career as a climber (Naar, 1996). Apparently, anxiety prevented Naar from detecting the relevant information and finding the correct solution to the motor problem confronted. Thus, anxiety may affect perception and, hence, the selection of actions.

The anxiety–performance relationship has been studied extensively and is one of the most widely investigated and debated areas in sport psychology (e.g., Woodman & Hardy, 2001).[1] A number of models have been put forward to describe and explain the relationship between anxiety and performance, such as the inverted-U hypothesis (e.g., Woodman & Hardy, 2001; Yerkes & Dodson, 1908), the drive theory of Hull and Spence (Hull, 1943; Spence & Spence, 1966), Apter's reversal theory (Apter, 1982; Kerr, 1997), Hanin's individualized zone of optimal functioning hypothesis (e.g., Hanin, 2000), the multidimensional models (Martens, Vealey, & Burton, 1990), and the cusp catastrophe model (Hardy, 1990, 1996). It is beyond the scope of this study to describe these models. Moreover, several excellent overviews of theories on anxiety and performance are available in the literature (e.g., Cox, 2002; Gould, Greenleaf, & Krane, 2002; Janelle, 2002; G. Jones, 1995; Landers & Boutcher, 1998; Raglin & Hanin, 2000; Weinberg, 1990; Woodman & Hardy, 2001).

Most important for now is that, despite the evolution of these models, the mechanisms underlying the relation between anxiety and performance are still poorly understood (e.g., Janelle, 2002; Mullen, Hardy, & Tattersall, 2005), as theorizing in anxiety research remains troubled by the absence of consistent experimental findings regarding the effect of anxiety on human motor performance (G. Jones, 1995; Kleine, 1990). One of the reasons for this state of affairs is probably the prevalence of product-oriented approaches in pertinent research that, by definition, ignore that the effect of anxiety on performance is mediated by a wide variety of processes (e.g., Collins, Jones, Fairweather, Doolan, & Priestley, 2001). To better understand this mediation, and thus to help disentangle the multifaceted relationship between anxiety and human motor performance, this study adopts a more process-oriented approach. Ecological psychology offers a conceptual framework for pursuing the latter kind of approach in the domain of interest, and as such provides, at least in our view, an expedient and promising theoretical framework for studying the influence of the actor's state variables, such as anxiety, fatigue, and anger, on perception and action, even though, admittedly, attempts in this direction have been few and far between.

In ecological psychology (J.J. Gibson, 1979/1986), perception is viewed as the active pickup of information specifying *affordances,* that is, the behavioral possibilities offered by the environment (also called *action possibilities* or *behavioral potential;* Bhalla & Proffitt, 1999; Proffitt, Bhalla, Gossweiler, & Midget, 1995). The theory

[1]Anxiety is conceived as a multidimensional construct having a cognitive component (i.e., worry, apprehension) and a physiological arousal component (i.e., the physiological response to anxiety-inducing situations; Martens et al., 1990).

of affordances provides a conceptual framework for understanding the interactions between actors (humans and other animals) and their environment. It is founded on the premise that the environment is perceived in action-relevant terms, that is, in terms of what the actor can do with and in the environment. If the environment affords a particular action for a particular actor (human or animal), then that actor possesses certain properties that allow that particular action to take place in the environment. In ecological psychology, the latter properties are sometimes referred to as *effectivities* (Shaw, Turvey, & Mace, 1982; Turvey, 1992; Turvey & Shaw, 1979). In that account, affordances and effectivities are seen as complementary dispositional properties, both of which are necessary conditions for the actor–environment system to exhibit an action (Turvey, 1992).[2]

If an actor is perceiving affordances while engaged in a particular activity, he or she must be capable of perceiving the relation between environmental properties and the properties of his or her own action system. By implication, actions are "body-scaled" (e.g., Warren, 1984, 1988). For example, to successfully reach for objects, people must scale the distance of the object in terms of their effective reach actions, which are constrained by geometric measures (e.g., arm length, leg length; see, e.g., Carello, Grosofsky, Reichel, Solomon, & Turvey, 1989; Mark, 1987; Mark et al., 1997; Warren, 1984, 1988). Initial research on affordances was focused on these "invariable" intrinsic anthropometric body measures such as leg length (Warren, 1984), or arm length (Carello et al., 1989). Konczak, Meeuwsen, and Cress (1992) emphasized that action capabilities are not exclusively defined by anthropometrics, but that most perceptual–motor tasks are also subject to additional biomechanical constraints such as strength, limb mobility, and joint flexibility. They demonstrated that the perception of affordances (judgment of climbability of stairs) needs to be related to observers' action capabilities, or, in Turvey's (1992) terminology, effectivities (see also Cesari, Formenti, & Olivato, 2003; Choi & Mark, 2004; Oudejans, Michaels, Bakker, & Dolné, 1996; Oudejans, Michaels, Van Dort, & Frissen, 1996; Pepping & Li, 2000).

So far the role of the actor's emotional state (i.e., anxiety or fatigue) in perceiving and realizing affordances has been addressed in only a few studies. Proffitt and Bhalla (Bhalla & Proffitt, 1999; Proffitt et al., 1995) conducted a series of experiments showing a relation between an actor's state and the perceived steepness of hills. They found that as hills are harder to traverse when participants are ex-

[2]In ecological psychology there is an ongoing debate about the concepts of affordances and effectivities (e.g., Chemero, 2003; Heft, 2003; Michaels, 2003; Stoffregen, 2000, 2003). For instance, Stoffregen (2003) argued that affordances should be defined as emergent properties at the level of the animal–environment system rather than as properties of the environment that require complementary properties of the animal, that is, effectivities. In this respect Stoffregen's definition of affordances differs qualitatively from that of Turvey (1992). However, irrespective of one's position in this discussion, it is important to identify and understand how properties of the animal–environment system constitute opportunities for action, including the role of the actor's emotional state in perceiving and realizing affordances.

hausted, wearing a heavy backpack, or older, the hills look steeper. It seems that the capacity to traverse a hill changes the perception of the steepness of the hill despite the fact that the actual steepness remains the same. Thus, there seems to be a functional adaptation of perception of action possibilities to the actual action capabilities.

Pijpers, Oudejans, and Bakker (2005b) confirmed such a relationship for overhead reachability, which they found to change as a function of exertion. On a climbing wall, participants repeatedly climbed series of trials resulting in increased levels of exertion. Before and during climbing participants judged their maximum reaching height, as well as perceived exertion. On a separate day, participants again climbed a number of trials while performing actual maximum reaches. Perceived maximal reaching height appeared to follow changes in action capabilities: When there were no changes in action capabilities—that is, no changes in actual maximal reaching height—no changes in perceived maximal reaching height occurred. Only when the actual maximal reaching height changed was this reflected in perceptual changes of maximal reaching height.

As far as we know, there is only one previous study that investigated the effects of anxiety on the perception of affordances. Bootsma, Bakker, Van Snippenberg, and Tdlohreg (1992) asked participants to judge whether balls that passed laterally at varying distances were reachable. They found that anxiety did not influence the average judgment of maximum reachable distance. However, Bootsma et al. did not examine whether anxiety had an effect on the actual maximum reaching distance. The selected affordance scaled with a physical characteristic (i.e., maximum reach, mainly determined by arm length), and was thus assumed not to be affected by the anxiety manipulation. However, as acknowledged by Bootsma et al., if an experimental manipulation directly affects the action capabilities of an observer, then a change in the perception of reachableness of approaching balls might be expected.

Thus, it seems that as long as participants' behavioral potential (i.e., actual action capabilities or effectivities) is not influenced by a state variable such as anxiety (or fatigue), one would expect that the perception of action possibilities is not influenced either. However, when a state variable does induce changes in a participant's behavioral potential, one would expect accompanying changes in the perception of the action possibility in question. The first goal of this study was to examine the role of anxiety in perceiving and realizing affordances. By using a climbing wall we determined perceived and actual maximal overhead reaching height under different anxiety conditions, which were created by placing the same climbing routes high and low on the wall (cf. Pijpers, Oudejans, & Bakker, 2005; Pijpers, Oudejans, Holsheimer, & Bakker, 2003). Overhead reaching and adequately perceiving overhead reachability are important to the performance of daily actions (e.g., grasping an item from the highest shelf in the supermarket), as well as in sports in which, for instance, a ball has to be caught or hit. Adequately perceiving overhead reachability is also essential in the task investigated in this study—

sport climbing—in which misperception may lead to falling. In Experiment 1, the effect of anxiety on perceived as well as actual maximal reaching height was investigated to determine whether changes in perceived maximal reaching height were accompanied by changes in actual maximal reaching height. In Experiment 2, we explored whether increased anxiety and the accompanying changes in perceived and actual maximal reaching height also affected participants' selection of action possibilities on the climbing wall. Finally, in Experiment 3, we investigated the impact of anxiety on attentional processes on the climbing wall.

EXPERIMENT 1

We expected that at higher levels of anxiety the actual maximal reaching height would decrease for two reasons. First, changing an individual's state (i.e., becoming more anxious) induces changes in movement execution such as higher muscle tension and jerkier, more rigid, and slower movements (e.g., Beuter & Duda, 1985; Collins et al., 2001; Mullen & Hardy, 2000; Pijpers et al., 2005; Weinberg, 1978). Second, reaching out as far as possible involves a chain of submovements such as stretching out the arm as far as possible; rotations in hips, back, and shoulders; stretching the legs; and standing on tiptoe; implying that any effect of anxiety on these submovements, however small, will result in a culmination of errors along an entire biokinematic chain, which enhances the possibilities for establishing anxiety effects on an outcome measure such as actual maximal reaching height (cf. Parfitt, Jones, & Hardy, 1990; Weinberg, 1990). In view of the theoretical considerations offered in the preceding, we further expected that the predicted decreases in actual maximal reaching height would be accompanied by decreases in perceived maximal height.

Method

Participants. A total of 12 female participants, mean age 23.0 years (SD = 1.21), volunteered to participate in the experiment. The participants, for the greater part university students, had no experience in climbing and were naive with regard to the purpose of the experiment. They all provided written informed consent.

The Dutch version of the A-Trait scale of the State–Trait Anxiety Inventory (STAI)[3] was used as a standard check to measure trait anxiety (Spielberger, Gorsuch, & Lushene, 1970; Van der Ploeg, Defares, & Spielberger, 1979). The mean trait anxiety score for the participants was 30.8 (SD = 6.28), and was signifi-

[3]The STAI A-Trait scale is a self-report questionnaire that measures anxiety proneness—that is, the tendency to respond to situations perceived as thrilling with an elevation in state anxiety intensity. Scores range from a low of 20 to a high of 80 (Van der Ploeg et al., 1979, 1980).

cantly lower than the mean score for Dutch female college students ($M = 37.7$, $SD = 8.4$) obtained by Van der Ploeg, Defares, and Spielberger (1980) on a t test between a sample and a population mean (Thomas & Nelson, 1996), $t(11) = 3.83$, $p < .05$. The results indicated that the participants had no extraordinary tendency to respond to situations perceived as threatening with an elevation in state anxiety (e.g., Martens, 1982; Smith, Smoll, & Wiechman, 1998).

Experimental setup. Participants climbed on a vertical climbing wall (width = 3.5 m, height = 7.0 m; see Figure 1), which was set up in a large experimental room. The wall consisted of nine laminate panels with a gray grainy texture for friction. Holds could be bolted anywhere on the wall at relative distances of 0.24 m in a horizontal direction, and 0.17 m in a vertical direction. On the wall, two identical horizontal routes (so-called traverses designed by a professional route designer) were mounted (see Figure 1). Each traverse consisted of six footholds and six handholds of varying size and shape, which were all suitable for novice climbers. The mean height of Holds 3 and 4 (see Figure 1) of the low traverse (*low* condition) and high traverse (*high* condition) were 0.30 m and 3.60 m, respectively. (Participants stood on these holds when judging maximal reachability; see Procedure.)

One hold, the "assessment hold" (the black rectangle, see Figure 1), was movable in vertical direction. This hold was used to estimate the upper limit that participants perceived they were able to reach (the dependent variable perceived maximum reaching height), and that participants could actually reach (the dependent variable actual maximal reaching height). The assessment hold could be moved freely along a rail, which was placed between the laminate panels of the wall and extended the entire height of the climbing wall (see Figure 1). The assessment hold was connected with ropes that could be used to pull the hold up or down. Reference points were removed by covering a part of the climbing wall (0.40 m on both sides of the rail) with black tape. (Post hoc interviews indicated that none of the participants made use of reference points when making their assessments.) A flexible tape measure was used to measure the distance between the assessment hold and Hold 4 (see Figure 1) after each assessment, to determine perceived and actual maximal reaching height. Hold 4 was chosen because it provided a "natural" basis from which the investigated reaching action (perceived or actual) took place, especially because reaching was done with the left arm (see Procedure).

To enable participants to make assessments in the high condition, a large stepladder was used. The stepladder had a small platform that allowed participants to rest after having climbed it and to start the high traverse in the same physical (i.e., nonfatigued) condition as in the low traverse.

The participants wore well-fitting climbing shoes (Enduro 954, La Sportiva). In both conditions participants wore a climbing harness (Singing Rock). We used the so-called "top-roping" technique to ensure the safety of the participants. Top-roping involves "paired" climbing (Skinner & McMullen, 1993), that is, one end of the rope was tied onto the participant's harness, and the safety rope ran

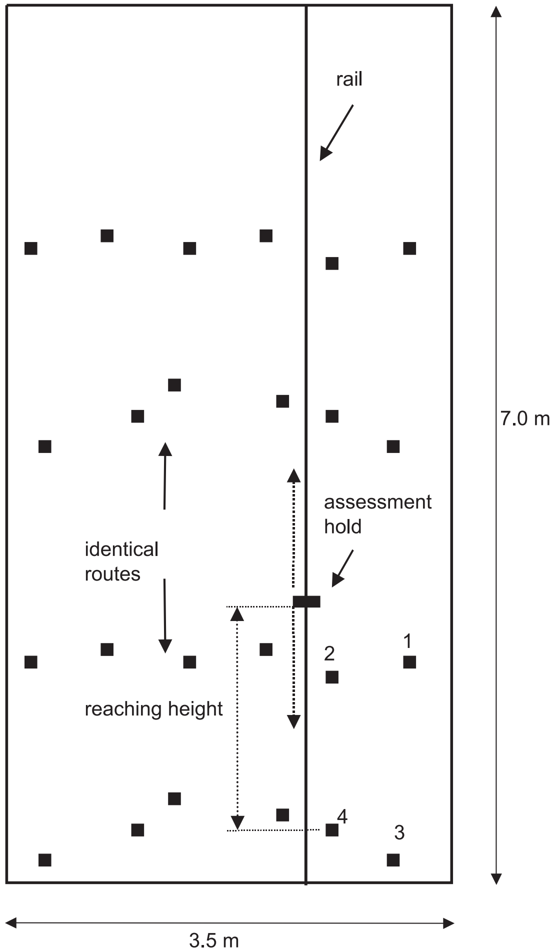

FIGURE 1 Front view of the layout of the climbing wall used in Experiment 1. Black squares indicate the positions of the holds. The routes in the low and high condition are identical. The assessment hold (indicated by the black rectangle) could be moved freely along the rail. Holds 1 through 4 indicate the position in which the perceptual judgments of maximum reaching height and actual maximum reaches were made (see also text).

up around a solid iron bar at the top of the climbing wall, and back to the ground. This end of the safety rope ran through the belay device on the belayer's harness. (The belayer is the person who manages the safety rope, preventing and protecting participants from falling if they lose their grip on the wall.) If properly applied, using the top-roping technique reduces the risk of a considerable fall to zero.

State anxiety was assessed by means of the "anxiety thermometer" validated by Houtman and Bakker (1989). The anxiety thermometer is a 10-cm continuous scale on which participants were asked to rate their anxiety feelings at a particular moment in time, ranging from 0 (*not anxious at all*) to 10 (*extremely anxious*). Participants had to place a cross on the 10-cm scale to indicate how they felt at a particular moment. The distance between the left end and cross (in mm) was used as a measure of the reported anxiety. Consequently, the anxiety thermometer provided a quick method for measuring state anxiety in contrast to the often-used Competitive State Anxiety Inventory-2 (Martens et al., 1990; for a critical discussion of the Competitive State Anxiety Inventory-2, see M. V. Jones & Uphill, 2004, and Woodman & Hardy, 2001), which would be unsuitable for our purposes (see also Pijpers et al., 2003). The validity and reproducibility of the anxiety thermometer are fair, with correlation coefficients ranging between .60 and .78. Based on these data, the anxiety thermometer is deemed an appropriate instrument for measuring anxiety in a threatening real-life situation (Houtman & Bakker, 1989). For each measurement, a separate anxiety thermometer was used.

During the assessments of perceived maximal reaching height, we recorded heart rate values every 5 sec using a Sporttester (Polar Electro-3000). Afterward, mean heart rate was calculated per condition. All assessments were videotaped using an S-VHS camcorder (sampling rate 50 Hz), allowing us to check specific aspects of the experiment if such a need arose.

Procedure. Participants were tested individually on a single day. Their total involvement in the experiment was approximately 1 hr. Participants were informed about the procedure of the experiment, and then asked to read and sign an informed consent statement. They completed the Dutch version of the STAI A-Trait scale (Van der Ploeg et al., 1979) and filled out an anxiety thermometer to familiarize themselves with this measuring device.

Participants were then briefed in detail about what was meant by *maximal reaching,* on which they had to base their estimates of maximal reaching height. For the purposes of this study, the maximal reaching height was defined according to the following reaching action (for the numbering of the holds low on the wall, see Figure 1): Each participant placed her left foot on Hold 4, right foot on Hold 3, right hand on Hold 1, and left hand on Hold 2, and then imagined that she would stretch upward as far as possible (keeping both feet on the holds; standing on tiptoe was allowed) using the left hand to grasp the assessment hold in such a way that it would be possible to hang onto it and to use it for climbing. Participants were not allowed to actually execute the reaching action.

Each participant was fitted with climbing shoes and harness, as well as a Sporttester. Prior to making the assessment of the perceived maximal reaching height participants were given the opportunity to practice on the wall, as brief hands-on experience with the task may yield perceptual information about climbing actions having a substantial impact on participants' estimations of maximal reaching height (Pijpers et al., in press).

Subsequently, participants were asked to take position on the wall. The assessment hold (see Figure 1) was either lowered from about 1.5 m above Hold 2 (descending assessment) or pulled up from about 1.5 m below Hold 2 (ascending assessment), during which the participants had to verbally indicate when the assessment hold would just be reachable in the prescribed manner. Participants could fine-tune their judgments by telling the experimenter to move the assessment hold either up or down until they were confident that the assessment hold was at the perceived maximal reaching height. Then, by means of the tape measure, the distance was determined to the nearest millimeter; for accuracy reasons we always read off the tape measure at eye level. The descending and ascending assessments were presented in alternating order. One trial consisted of one descending and one ascending assessment. Consistent with previous research on perceptual judgment tasks using the method of limits (e.g., Mark, 1987; Mark, Balliett, Craver, Douglas, & Fox, 1990; Pufall & Dunbar, 1992), the average of the three descending/ascending combinations (i.e., three trials) was used as measure of perceived maximal reaching height for a given condition. Participants received no feedback about the accuracy of their assessments.

Perceptual judgments were made in a similar way high and low on the wall (high and low conditions were counterbalanced). In each condition participants performed three descending and three ascending trials. Immediately after each condition participants were asked to rate their feelings of anxiety by means of the anxiety thermometer. Participants were asked to recall how anxious they had felt during the assessments and to record this on the anxiety thermometer scale. This was used as the anxiety score for the condition in question.[4]

Participants were allowed a recuperation period of about 10 min after each condition. After the two perceptual judgment conditions, participants' actual maximal reaching height was determined: In both "actual" conditions, the participant stood on the footholds (right foot on Hold 3, left foot on Hold 4), grasped Hold 1 with her right hand (see Figure 1), and stretched out as high as possible with her left hand while the experimenter positioned the assessment hold in such a way that hanging onto it was just possible. The height of the assessment hold was measured. This procedure was repeated once; just as with the perceptual judgments, the mean of

[4]In retrospect, it might have been better if we had also asked participants to rate their feelings of anxiety briefly after performing the maximal reaches. However, as perceptual assessments and actual reaches were executed within the brief time span of about 25 min, we had (and still have) no reason to believe that participants' anxiety would have been different during the actual reaches in comparison to the perceptual assessments. Moreover, we found significant differences in anxiety between the high and low conditions on this climbing wall in all the climbing experiments that we performed (e.g., Pijpers et al., 2003, 2005). Even if participants had to climb high on the wall twice in the same experiment, anxiety was still significantly higher than in the low condition during the second time high on the wall (Pijpers et al., 2005).

the (two) assessments was the participants' maximal reaching height for the condition in question.

One of the experimenters served as belayer. In the low condition, the belayer acted so as to ensure that both conditions were similar for the climber. Each participant was informed before starting the climb in the low condition (mean height of the footholds, 0.4 m) that, despite the belayer, if she slipped she should break her fall herself, as the safety procedure would not be effective at that climbing height.

Statistical analysis. The effect of height (low-anxiety condition, high-anxiety condition) was tested using one-tailed paired *t* tests. Effect sizes (*ES*), indicating how many standard deviations the means under consideration differed, were calculated by taking the ratio of the difference between the two means and the mean within-cell standard deviation of the means (Mullineaux, Bartlett, & Bennett, 2001; Thomas & Nelson, 1996). Effect sizes of 0.2 or less, about 0.5, and 0.8 or more represent small, moderate, and large differences, respectively (Cohen, 1988). When necessary, two-factor repeated measures analyses of variance (ANOVAs) were used. Maughly's test of sphericity was used to determine whether there were any violations to sphericity for the repeated measures. If violations occurred, they were corrected according to the Huynh-Feldt procedure before determining whether the differences of interest were significant (Kinnear & Gray, 2000). Eta squared (η^2) assessed the explained variance in the ANOVA models. Pair-wise comparisons using *t* tests were made using the Bonferroni correction procedure (Kinnear & Gray, 2000) to identify specific mean differences when a significant main effect was found. The *p* values that are reported on the basis of this Bonferroni method are scaled to the .05 alpha level so that, as usual, *p* values smaller than .05 indicate a significant effect.

Results

State anxiety and heart rate. To determine whether the anxiety manipulation was successful, we performed a paired *t* test on both the anxiety thermometer data and the heart rate data. Participants reported significantly higher anxiety scores in the high condition ($M = 4.5$, $SD = 2.52$) than in the low condition ($M = 1.7$, $SD = 1.57$), $t(11) = 3.96$, $p = .001$, $ES = 1.35$. In addition, the mean heart rate (beats per minute or bpm) was significantly higher in the high condition ($M = 119.1$ bpm, $SD = 16.62$) than in the low condition ($M = 108.9$ bpm, $SD = 16.97$), $t(11) = 2.87$, $p = .008$, $ES = 0.61$. Thus, according to both measures, the manipulation of anxiety was successful—that is, in the high condition, participants were more anxious than in the low condition, implying that the high and low conditions indeed represented high-anxiety and a low-anxiety conditions, respectively.

Actual maximal reaching height. The average actual maximal reaching height was lower in the high condition than in the low condition (see Table 1). This

TABLE 1
Actual Maximal Reaching Height[a] and Perceived Maximal Reaching Height[a] for the Conditions in Experiment 1

	Condition			
	Low-Anxiety		*High-Anxiety*	
Variable	M	*SD*	M	*SD*
Actual maximal reaching height	209.4	11.43	207.1	10.48
Perceived maximal reaching height	207.6	11.36	204.0	11.34
Trial 1	207.8	11.35	204.6	10.13
Trial 2	207.6	12.13	204.1	11.00
Trial 3	207.5	11.34	203.2	10.98

[a]In cm.

difference was marginally significant, $t(11) = 1.77$, $p = .052$, $ES = 0.20$, indicating that higher levels of anxiety seemed to have affected participants' actual maximal reaching.

Perceived maximal reaching height. A 2 (Height: low-anxiety condition, high-anxiety condition) × 3 (Trial: Trial 1–3) repeated measures ANOVA on the perceived maximal reaching height data (see Table 1) revealed a significant main effect of height, $F(1, 11) = 8.73$, $p = .013$, $\eta^2 = 0.44$, $ES = 0.34$, indicating that the average perceived maximal reaching height was significantly lower in the high-anxiety condition than in the low-anxiety condition. The main effect of trial and the interaction between height and trial were not statistically significant (Fs < 1).

Discussion

Self-reported scores indicated that participants felt more anxious in the high condition (anxiety thermometer score: 4.5) than in the low condition (anxiety thermometer score: 1.7). A score of 4.5 on a 10-point scale might be taken to imply that the anxiety was relatively low. However, a score of 4.5 indicates that participants felt more anxious than students who are about to enter a written examination (Houtman & Bakker, 1989), about as anxious as novice teachers just before a lecture (Houtman, 1990), and less anxious than youth speed skaters prior to the start of a 1500 m race at a national championship (Bakker, Vanden Auweele, & Moormann, 1992). In addition to the subjective experience, heart rate appeared to be significantly higher when participants were high on the climbing wall than when they were low on the climbing wall. Thus, despite the fact that we selected a low trait anxious sample of women, the results clearly indicated that the anxiety manipulation was successful.

The results showed that in the high-anxiety condition, participants' actual maximal reaching height was lower than in the low-anxiety condition, although the difference just failed to reach the 5% significance level. The decrease in actual maximal reaching height was accompanied by a decrease in perceived maximal reaching height. This finding is consistent with the theoretical expectation that the perception of affordances changes only as the accompanying action capabilities change (Bootsma et al., 1992; J.J. Gibson, 1979/1986). The decrease in actual maximal reaching height is also in keeping with anxiety-induced changes in movement execution, such as more muscle tension and jerkier and slower movements (Pijpers et al., 2003, 2005; Weinberg, 1978; Weinberg & Hunt, 1976).

Note that the absolute difference between the low-anxiety condition and the high-anxiety condition was (only) 2.3 cm for the actual maximal reaching height and 3.6 cm for the perceived maximal reaching height. However, in both cases, the range over which changes are to be expected is small. As for actual maximal reaching height, the values are comparable to loss in stature due to spinal shrinkage. Values of spinal shrinkage due to circadian variations as well as spinal compression that are reported in the literature vary from a few mm up to over 1 cm or up to 1% (see Van Dieën & Toussaint, 1993), implying a reduction of about 1.7 to 1.8 cm for 1.7 m tall persons, the mean height of our participants ($SD = 0.04$). In light of these numbers, an average momentary reduction of actual maximal reaching height of 2.3 cm due to anxiety can be considered substantial. Regarding perceived maximal reaching height, as participants' height was on average 1.7 m, it is highly unlikely that participants judged their maximal reach lower than 1.7 m. The range over which the judgments were made was maximally 40 cm, and probably even less. As such, the observed difference of 3.6 cm may also be viewed as substantial.

The question remains whether the anxiety-induced changes in perceived and actual maximal reaching height also lead to changes in the realization of action possibilities. For example, if one perceives a particular hold on the climbing wall as just reachable in a neutral condition but as no longer reachable when anxious, does that also lead to the selection of a hold that is safely within reach if such a hold is available? In Experiment 2, we addressed this question by examining whether anxiety and accompanying changes in perceived and actual maximal reaching height also affected participants' selection of action possibilities on the climbing wall, and, consequently, movement behavior.

EXPERIMENT 2

We asked participants to climb a horizontal traverse in two anxiety conditions, low (low-anxiety condition) and high (high-anxiety condition) on the climbing wall. To ensure that participants had the opportunity to select more holds than strictly necessary to climb the traverse, an abundance of holds (30) was used in building the traverse (see Figure 2). Previous studies (Pijpers et al., 2003, 2005) had demon-

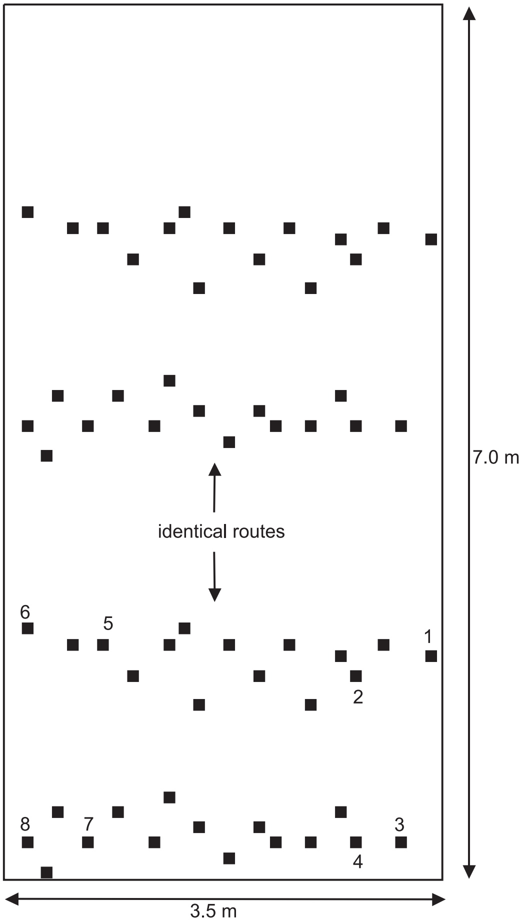

FIGURE 2 Front view of the climbing wall used in Experiment 2. The routes in the low and high condition are identical. The positions of the holds are indicated by black squares. Holds 1 through 4 indicate the starting position. See text for explanation of Holds 5 through 8.

strated that a traverse consisting of 11 holds sufficed to climb from left to right on the same climbing wall. As the same hold could be used multiple times in climbing a traverse, we operationalized the selection of action possibilities by counting the number of movements made to climb the traverse. In doing so, we distinguished between performatory movements and exploratory movements (E.J. Gibson, 1988). Performatory movements are meant to reach a certain goal, for instance, moving a hand or foot from one hold to the next to use it as support for further climbing actions. Exploratory movements are primarily information gathering movements, for example, when a climber wants to explore whether a hold is within reach. We predicted that the participants would make both more performatory and more exploratory movements in executing the climbing task in the high-anxiety condition than in the low-anxiety condition.

Method

Participants. A total of 12 participants, 6 men and 6 women,[5] mean age 20.8 years ($SD = 3.57$) volunteered to participate in the experiment. None of them had participated in Experiment 1. The participants, all college students, had no experience in climbing and were naive to the purpose of the experiment. All provided informed consent.

The mean trait anxiety score for the male participants was 34.8 ($SD = 4.26$), and was not significantly different from the mean score for Dutch male college students ($M = 36.1$, $SD = 8.4$) obtained by Van der Ploeg et al. (1980) on a t test between a sample and a population mean (Thomas & Nelson, 1996), $t(5) = 0.73$, *ns*. The mean trait anxiety score for the female participants was 34.0 ($SD = 5.66$), and was not significantly different from the mean score for Dutch female college students ($M = 37.7$, $SD = 8.4$; Van der Ploeg et al., 1980), $t(5) = 1.60$, *ns*. The results indicated that the participants had no extraordinary predisposition to respond across many situations with high levels of state anxiety (e.g., Smith et al., 1998).

Experimental setup. Participants climbed on the same climbing wall as that used in Experiment 1. Again, two identical horizontal routes were mounted low and high on the wall, each consisting of 15 footholds and 15 handholds (see Figure 2). The mean height of the footholds of the low traverse was 0.36 m (low-anxiety condition) whereas that of the high traverse was 3.69 m (high-anxiety condition). To enable participants to start climbing in the high condition, the stepladder was again used.

As in Experiment 1, participants wore well-fitting climbing shoes and a climbing harness connected to a climbing rope. The same security procedure as in Experiment 1 was used. All climbs were videotaped using an S-VHS camcorder (sampling rate of 50 Hz); participants' hand and foot movements were clearly visible. We used a stopwatch to determine climbing time (see Dependent Variables section for a definition of this variable).

State and trait anxiety were measured in the same way as in Experiment 1. We decided not to use heart rate as a measure of state anxiety because a higher heart rate in the high condition is also a reflection of physical strain. Increased climbing

[5]In both Experiments 2 and 3, mixed samples of men and women were tested. We checked whether there were significant differences between males and females on the state anxiety scores as well as the performance measures reported in Experiments 2 and 3. No significant effects involving gender were obtained.

time in the high-anxiety condition is a consistent and robust finding in studies like this one (cf. Pijpers et al., 2003, 2005).

Task execution. Participants were instructed to climb as fast and as safely as possible but it was stressed that the participant's first goal should be to complete the climbing task without falling. Each participant was told that a fall would immediately end the experiment, and that the participant would be excluded from the experiment and subsequent analyses. During the experiment, none of the participants fell. No instructions were given as to how to climb faster or which holds to use.

Procedure. Participants were tested individually on a single day. They were informed about the procedure of the experiment, after which participants signed an informed consent statement. They completed the Dutch version of the STAI A-Trait scale (Van der Ploeg et al., 1979).

After putting on their climbing shoes and harness, participants practiced climbing on the climbing wall. As the number of holds was more than sufficient to climb from the right side of the climbing wall to the left side and back again to the right side, all participants were able to successfully complete the practice task within a few minutes. As a consequence, the experimenters were confident that a participant's failure to complete the task in either condition was not due to lack of experience with the task.

After practice, participants were allowed 15 min to recuperate. Three minutes prior to running each condition, participants were positioned in front of the wall, either on the floor or the stepladder, depending on the condition in question. Two minutes before the climb, participants were asked to indicate how anxious they were at that moment by filling out an anxiety thermometer to familiarize themselves with the thermometer. Then, participants were connected to the safety rope. The camcorder was switched on and participants were instructed to begin when ready by assuming the starting position on the wall. A participant was considered to be in the starting position when he or she had placed the right hand on Hold 1, left hand on Hold 2, right foot on Hold 3, and left foot on Hold 4 (see Figure 2). As soon as participants had assumed the starting position in the high condition, the stepladder was quickly removed. In the low condition, participants were instructed not to start climbing immediately, but to wait just as long as it would have taken to relocate the stepladder in the high condition (less than 10 sec). In both conditions participants started climbing at a sign from one of the experimenters. Participants resumed the same position after they had climbed the traverse two times. Hence, participants climbed the traverse from the right to the left (ending with the right hand on Hold 5, left hand on Hold 6, right foot on Hold 7, and left foot on Hold 8; see Figure 2), and back to the right again. Immediately after the climb, the participants were asked to recall how anxious they had felt during the climb and to record this on the anxiety thermometer. This anxiety score was used as an anxiety score for that climb (and thus, for that condition).

After a recuperation period of at least .5 hr the procedure was repeated, but now participants climbed in the other condition (high if they had started low; low if they had started high). The order of high and low conditions was reversed with each new participant (balanced over male and female participants).

Dependent variables. For each condition, the following dependent variables were determined from the videotapes:

1. *Number of performatory movements,* defined as the number of movements during which a hold is released and contact is made with another hold, which is then used as support.
2. *Number of exploratory movements*, defined as the number of times a hold was touched without it being used as support.

Participants' movements were viewed by two independent raters for accurate determination of the dependent variables just mentioned. There was a 100% interobserver agreement regarding performatory as well as exploratory movements.

3. *Climbing time* was also registered for each condition; it was defined as the sum of the time needed to climb the two traverses (from the right to the left, and back). As soon as participants released one of the holds in the starting position, time started. When participants had returned to the starting position, the time was stopped.

Statistical analysis. See Experiment 1.

Results

State anxiety. Participants reported significantly higher anxiety scores in the high condition ($M = 4.8$, $SD = 1.81$) than in the low condition ($M = 2.2$, $SD = 1.98$), $t(11) = 5.32$, $p = .0001$, $ES = 1.33$, indicating that the anxiety manipulation was again successful.

Behavioral variables. Table 2 presents an overview of the results concerning number of performatory movements (hand and foot movements), number of exploratory movements, and climbing time. The number of performatory movements was significantly higher in the high condition than in the low condition, $t(11) = 3.00$, $p = .006$, $ES = 1.08$. Investigating hand and foot movements separately, it appeared that significantly more performatory hand movements were made in the high condition than in the low condition, $t(11) = 3.90$, $p = .001$, $ES = 1.21$, as well as significantly more performatory foot movements, $t(11) = 2.11$, $p = .029$, $ES = 0.76$. Also the number of exploratory movements was significantly larger in the high condition than in the low condition, $t(11) = 2.76$, $p = .009$, $ES = 1.14$. Both the number of exploratory hand movements and the number of ex-

TABLE 2
Number of Performatory Movements, Number of Exploratory Movements, and Climbing Time[a] for the Conditions in Experiment 2

	Condition			
	Low-Anxiety		*High-Anxiety*	
Variable	M	*SD*	M	*SD*
Number of performatory movements	40.0	5.80	47.5	7.97
Hand movements	20.9	3.18	24.8	3.30
Foot movements	19.1	3.75	22.7	5.69
Number of exploratory movements	1.3	2.10	6.3	6.67
Hand movements	0.9	1.44	5.1	5.74
Foot movements	0.4	1.00	1.3	1.22
Climbing time	45.8	12.8	78.8	25.4

[a]In sec.

ploratory foot movements were higher in the high-anxiety condition than in the low-anxiety condition, $t(11) = 2.47$, $p = .016$, $ES = 1.59$, and $t(11) = 2.80$, $p = .009$, $ES = 0.75$, respectively.

It appeared that climbing time increased significantly from 45.8 sec in the low condition to 78.8 sec in the high condition, $t(11) = 5.62$, $p < .0001$, $ES = 1.73$. There were large individual differences in climbing time, causing the large standard deviations. In the low condition, climbing time ranged from 27 to 69 sec, and in the high condition from 54 to 143 sec.

Discussion

As expected, in the high-anxiety condition, the abundance of alternatives to climb the traverse (provided by more holds) resulted in more movements, both performatory and exploratory. This indicates that a person's internal state plays a role in perceiving and realizing action possibilities: Across anxiety conditions, participants selected different action possibilities from the plethora of action possibilities afforded by the environment.

In Experiment 1 it was found that changes in perceived and actual maximal reaching height occurred due to anxiety. These changes may partly account for the effects observed in Experiment 2. However, it is questionable whether the differences in perceived and actual reachability, which were in the order of magnitude of several centimeters, can fully explain why participants made so many more (performatory and exploratory) movements in the high-anxiety condition than in the low-anxiety condition. Note that using more holds implies shifts in grasping distance of (at least) 17 cm, as the holds were 17 cm apart in vertical direction and 24 cm in horizontal direction, whereas changes in perceived and actual abilities were "only" a few centimeters. It may be that on top of the changes in perceived and actual maximal reaching height, anxiety induced changes in participants' detection of relevant information for climbing, that is, in attention. Shifts in attention have been identified as one of the key mechanisms underlying changes (mostly decrements) in performance due to anxiety (Baddeley, 1972; Beilock & Carr, 2001; Janelle, Singer, & Williams, 1999; Landers, Wang, & Courtet, 1985; Liao & Masters, 2002; Mullen et al., 2005; Weltman & Egstrom, 1966; Weltman, Smith, & Egstrom, 1971). As attentional mechanisms might underlie the anxiety-induced changes in perception and realization of action possibilities that were found in Experiments 1 and 2, a third experiment was conducted to examine the relation between anxiety and attention in the climbing task.

EXPERIMENT 3

Two major accounts have been suggested in the literature to explain changes in attention due to anxiety (see Beilock & Carr, 2001; Janelle et al., 1999; Moran, Byrne, & McGlade, 2002). First, Easterbrook's (1959) cue-utilization theory states that as one experiences greater anxiety, the attentional field narrows (cf. Bacon, 1974; Janelle et al., 1999; Williams & Elliott, 1999). As a result, performance on central tasks will first be facilitated at the expense of performance on peripheral tasks, as peripheral (irrelevant) information will be blocked. At even higher anxiety levels, this funneling effect may also prohibit attention to the information sources relevant for the central task, resulting in a decrement in performance on this central task. Second, performance decrements under stressful conditions can also be explained by the notion that anxious people are more easily distracted (Eysenck, 1992; Janelle et al., 1999). Within the distraction models, it is proposed that some stimuli shift attention away from task-relevant information to task-irrelevant cues, thereby decreasing performance (see also Moran, 1996). It is assumed that increased pressure will cause individuals to focus on distracting stimuli either externally (e.g., crowd noise) or internally (e.g., worries) instead of focusing on task execution per se.

Although originating from an information-processing approach, attentional narrowing and distraction are not necessarily inconsistent with an ecological perspective. In ecological terms, attentional narrowing would imply missing less useful or nonspecifying information[6] when anxiety increases. When anxiety increases

[6]A nonspecifying information source may be related to a to-be-perceived property, but it is not specific to it, as its value does not under all circumstances reliably predict the value of the to-be-perceived property (Beek, Jacobs, Daffertshofer, & Huys, 2003). Specifying information sources are specific to (to-be-perceived) properties of the environment. This means that detecting a certain information source that specifies a property of the environment allows the observer to make reliable judgments about this property (Beek et al., 2003).

further, one might even start missing task-specific, specifying information, as a result of which the performance of the main task would be hampered.

Distraction would imply changes in the degree to which useful and less useful information draw the actor's attention. In terms of ecological psychology, there are changes in the "attensity" of information surrounding the actor, with *attensity* defined as "a measure of the attraction that an area of information has for a perceiver" (Michaels & Carello, 1981, p. 71).

Based on the results of Experiments 1 and 2, one would expect that, of these two mechanisms, attentional narrowing in particular would play a role high on the climbing wall. Therefore, in Experiment 3, we again asked novices to perform a climbing task in low-anxiety and high-anxiety conditions. In both conditions, participants now simultaneously had to respond as quickly as possible to the appearance of a series of red lights projected on the climbing wall. If, as expected, attentional narrowing were to occur, participants would focus more on the primary climbing task and consequently detect fewer projected lights in the high-anxiety condition than in the low-anxiety condition, or they would at least respond more slowly to the detected lights if the number of detected lights remained the same. If, contrary to our expectations, (external) distraction were to prevail (implying enhanced susceptibility to peripheral distractors, Williams & Elliott, 1999), one would expect that, in the high-anxiety condition, participants would detect the same number or more projected lights with the same or a quicker response time than in the low-anxiety condition.

Method

Participants. A total of 17 participants, 5 men and 12 women, mean age 21.4 years ($SD = 2.42$) volunteered to participate in the experiment. The participants, all college students, had no experience in climbing and were naive to the purpose of the experiment. None of them had participated in Experiments 1 or 2. All provided informed consent.

The mean trait anxiety score for the male participants was 28.6 ($SD = 4.93$) and was significantly lower than the mean score for Dutch male college students ($M = 36.1$, $SD = 8.4$) obtained by Van der Ploeg et al. (1980) on a t test between a sample and a population mean (Thomas & Nelson, 1996), $t(4) = 3.40$, $p < .05$. The mean trait anxiety score for the female participants was 33.8 ($SD = 7.52$), and was not significantly different from the mean score for Dutch female college students ($M = 37.7$, $SD = 8.4$, Van der Ploeg et al., 1980), $t(11) = 1.80$, *ns*. The results indicated that the participants had no extraordinary predisposition to respond across many situations with high levels of state anxiety (e.g., Smith et al., 1998).

Task execution. Participants were instructed to climb as fast and as safely as possible; however, their primary goal was to complete the climbing task without falling. They were told that a fall would immediately end the experiment, and that the participant would be excluded from the experiment and subsequent analyses. Participants had to climb the traverse four times—that is, starting at the left side of the wall, the participants climbed to the right side (Traverse 1), then returned to the left side (Traverse 2), back again to the right side (Traverse 3), and back again to the left side of the wall (Traverse 4). It was also emphasized that participants should say out loud "Yes" as quickly as possible when they observed a red light that was projected on the climbing wall. Participants were informed that both tasks were equally important in terms of the overall performance score.

During the experiment, none of the participants fell. No instructions were given with respect to how to climb faster, or which holds to use.

Experimental setup. Participants climbed on the same climbing wall as that used in Experiments 1 and 2. Again, two identical horizontal routes were mounted low and high on the wall, each consisting of five footholds and six handholds (see Figure 3). The mean height of the footholds of the low traverse was 0.34 m (low-anxiety condition), whereas that of the high traverse was 3.68 m (high-anxiety condition). To enable participants to start climbing in the high condition, the stepladder was again used (see Experiments 1 and 2).

For the peripheral light detection task, laser lights were projected on the climbing wall in the vicinity of the participants while they were climbing the traverse. For this purpose, we developed a so-called laser pointer system (LP system; see Figure 4). The LP system consisted of a box with five laser pointers attached to it. There were four peripheral pointers and one central pointer. The LP system was placed on a 1.31-m-high tripod at a distance of 7 m from the climbing wall. The laser pointers could be moved around a ball-and-socket joint to adjust the direction of the light beam and hence the projection of the lights on the climbing wall. With a handle attached to the LP system, the central laser pointer (labeled "ML", i.e., marker light; see Figure 4) could be moved up and down, and from the right to the left, making it possible to direct it continuously on a marker on the participant's back while he or she was climbing on the wall. Consequently, the four peripheral laser pointers projected their lights at (almost) the same distances from the participants irrespective of their climbing actions. In the high condition, the LP system was directed upward, and the angles of the laser beams were adjusted to keep the positions of the lights relative to the participant identical to those in the low condition.

The locations of the peripherally projected lights were (see Figure 4): right of the right shoulder (labeled "RS"), left of the left shoulder (labeled "LS"), right of the right hip (labeled "RH"), and left of the left hip (labeled "LH"). The LP system was connected with a PC. By means of a specially developed software program (LabVIEW; Version 6.1; National Instruments; Austin, Texas) it was possible to set the frequency, duration, and order of light activation of the laser pointers. During Traverses 1 and 3, the order of the lights projected on the climbing wall was set as follows: RS, RH, LH, and LS. During Traverses 2 and 4 the order was LS, RH, LH,

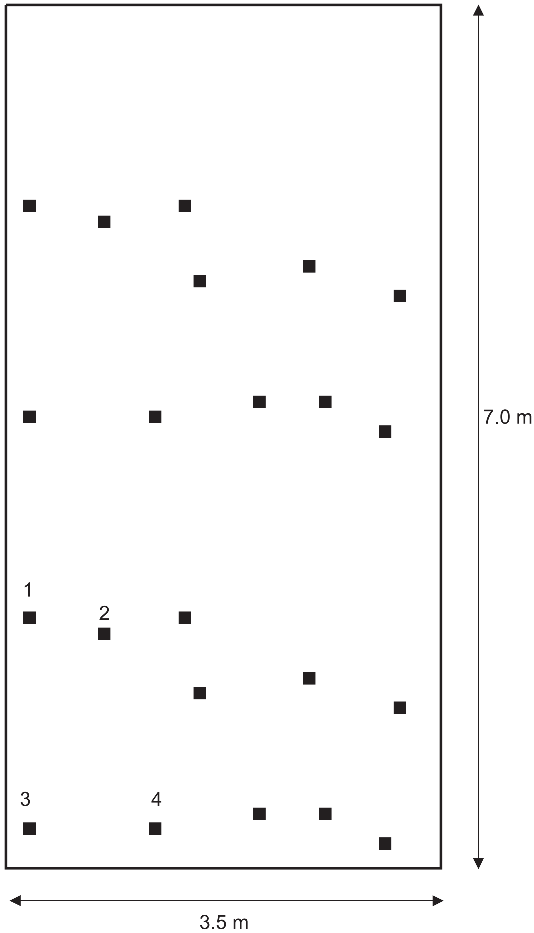

FIGURE 3 Front view of the climbing wall used in Experiment 3. The routes in the low and high condition are identical. The positions of the holds are indicated by black squares. Holds 1–4 indicate the starting position.

and RS. Every 3.5 sec a light was projected on the wall for 500 ms. The windows in the laboratory were blinded so that the light intensity was constant during the testing period. A stickpin microphone (also connected to the computer) with a basic amplifier was used to pick up the participant's "Yes" to calculate his or her response time (see also the Dependent Variables section). The software also provided a graphical representation of the moments laser pointers were switched on and off (and which laser pointer), and participants' verbal responses to the appearance of the lights (by means of whimsical bursts in the output signal).

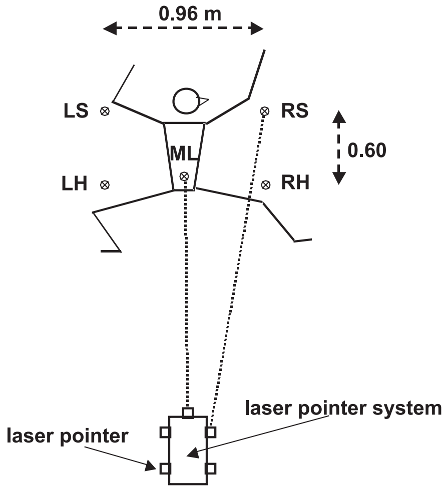

FIGURE 4 Projection of the four peripheral lights on the climbing wall (LS = left shoulder, LH = left hip, RS = right shoulder, and RH = right hip). The central pointer (ML = marker light) was continuously directed at the marker on the participant's back.

As in Experiments 1 and 2, participants wore well-fitting climbing shoes and an integral harness connected to a climbing rope. The same security procedure as in Experiments 1 and 2 was used. All climbs were videotaped using an S-VHS camcorder (sampling rate of 50 Hz). The camcorder was placed next to the LP system. State and trait anxiety were measured in the same way as in Experiment 2.

Procedure. Participants were tested individually on a single day. The entire procedure was explained to each participant, and questions concerning the experiment were answered. Participants were then asked to read and sign an informed consent statement. After each participant had completed the Dutch version of the STAI A-Trait scale (Van der Ploeg et al., 1979), the microphone was placed, and the participant put on climbing shoes and a harness. The participant then practiced the low traverse until he or she was able to climb the traverse two times back and forth. Practice periods lasted about 5 to 10 min. Then the lights were presented on the climbing wall after the participant had taken position on the wall to (a) familiarize the participant with the procedure and (b) make sure that the lights fell within his or her peripheral visual field, which was the case for all participants. After this, participants were allowed to pause for at least 15 min.

Subsequently, the participants' task was explained in detail: specifically, they were told that the climbing task had to be carried out as fast and safely as possible, and that at the same time they had to say out loud "Yes" as quickly as possible each time they observed a red light. One minute before the climb participants were asked to indicate how anxious they were at that moment by completing the anxiety thermometer, again for the purpose of familiarization. The participant was then led to the climbing wall and connected to the rope. The camcorder was switched on, and the participant was asked to take position on the wall: The participant placed the left hand on Hold 1, right hand on Hold 2, left foot on Hold 3, and right foot on Hold 4 (starting position; see Figure 3). As soon as participants had assumed the starting position in the high condition, the stepladder was quickly removed. In the low condition, participants were instructed to not start climbing immediately, but to wait just as long as it would have taken to reposition the stepladder in the high condition (less than 10 sec). In both conditions participants started at a sign from one of the experimenters. They then climbed the traverse four times.

Immediately after each condition, participants were asked to recall how anxious they had felt *during* climbing and to record this on the anxiety thermometer scale. This was used as anxiety score for the condition in question. High and low conditions were counterbalanced.

The participant was allowed a recuperation period of about 30 min before starting the second condition. No feedback about his or her performance was given. The second condition was executed in a similar fashion as the first, but now the participant climbed in the other condition (low if the participant had started high, high if he or she had started low).

Dependent variables. For each condition the following dependent variables were determined:

Number of detected lights, defined as the number of lights observed by the participant during climbing.

Response time, operationalized as the time between switching on a laser pointer and the participant's verbal response to it.

Climbing time, defined as the time needed to climb the traverse four times. Climbing time started as soon as the participant had left the starting position and stopped as soon as the participant had resumed the starting position after climbing the traverse four times. Climbing time was determined from the videotape.

Statistical analyses. See Experiment 1.

Results

State anxiety. Participants had significantly higher anxiety scores in the high condition (M = 5.0, SD = 2.56) than in the low condition (M = 2.4, SD = 2.40), $t(16) = 4.23$, $p = .0003$, $ES = 1.04$. Thus, the manipulation of anxiety was again successful: participants were more anxious in the high condition than in the low condition.

Performance on the climbing task. As in our previous studies (Pijpers et al., 2003, 2005), the climbing time in the high condition (M = 107.5 sec, SD = 27.10) was significantly longer than in the low condition (M = 88.4 sec, SD = 16.58), $t(16) = 4.66$, $p = .0001$, $ES = 0.88$. There were large individual differences in climbing time: In the low condition climbing time ranged from 69 to 137 sec, and in the high condition from 73 to 175 sec.

Performance on the light detection task. Due to differences in the average climbing times, the average number of lights that could be detected was 26.9 (SD = 6.78) in the high condition and 22.1 (SD = 4.15) in the low condition. Nevertheless, participants detected, on average, significantly fewer lights in the high condition (M = 3.7, SD = 3.10) than in the low condition (M = 6.5, SD = 3.47), $t(16) = 3.51$, $p = .001$, $ES = 0.85$. To diminish the confounding effect of climbing speed, we first determined which lights could have been detected by each participant. As the fastest participant needed 69 sec to execute the task—that is, about 17 sec per traverse—this participant could maximally have detected four lights per traverse. Therefore, we determined for each participant which lights were detected of the first four lights that were presented in Traverse 1, Traverse 2, Traverse 3, and Traverse 4. Each participant, including the fastest, could, in principle, have detected these first four lights per traverse, thus, 16 in total. Also according to this analysis, participants detected significantly fewer lights in the high-anxiety condition (M = 2.2, SD = 1.64) than in the low-anxiety condition (M = 4.6, SD = 1.91), $t(16) = 4.86$, $p < .0001$, $ES = 1.35$.

The 16 lights that could have been detected by all participants can be classified into lights that were presented in the direction of locomotion (the so-called ahead detections), and lights that were presented in the opposite direction (the so-called behind detections). A 2 (Height: low condition, high condition) $\times$ 2 (Direction of locomotion: ahead, behind) repeated measures ANOVA on the detection data revealed a significant main effect of height, $F(1, 16) = 23.57$, $p < .001$, $ES = 1.33$, $\eta^2 = .60$, and a significant main effect of direction of locomotion, $F(1, 16) = 41.43$, $p < .001$, $ES = 1.43$, $\eta^2 = .72$, indicating that, on average, significantly more ahead lights were detected (M = 2.6, SD = 1.59) than behind lights (M = 0.8, SD = 1.05). The interaction between height and direction of locomotion was not significant, $F(1, 16) = 1.66$, $p = .22$.

The average response time was not significantly different between the high condition (M = 742 ms, SD = 217.5) and the low condition (M = 774 ms, SD = 242.7), $t < 1$.

Discussion

Findings generally confirmed the notion of attentional narrowing (Bacon, 1974; Easterbrook, 1959; see also Murray & Janelle, 2003) in that participants detected fewer lights in the high-anxiety condition than in the low-anxiety condition. Apparently, in the high-anxiety condition attention was more narrowly focused on information relevant for climbing, whereas information that was less relevant for climbing at that moment (projected lights) was overlooked.

It should be noted that under anxiety the reduction in the number of lights detected occurred despite the fact that in the low-anxiety condition the number of lights detected was already low (about 25%). In the analyses presented in the preceding section, which were based on 16 lights (8 ahead and 8 behind lights), 43% of the ahead and 15% of the behind lights were detected in the low-anxiety condition. This indicates that "merely" climbing on the climbing wall is already attention consuming. In the high-anxiety condition only 23% of the ahead lights and 4% of the behind lights were detected, showing that almost all of the lights projected behind the climbers were missed and only a fourth of the lights projected in front of the climbers were detected.

In short, the results point in the direction of attentional narrowing because more lights went undetected in the high-anxiety condition. However, as Janelle et al. (1999) remarked, the mechanisms of attentional narrowing and distraction could be operative simultaneously. Instead of focusing on task execution per se (climbing and detecting lights), participants may have been focusing on internally distracting stimuli such as worries and negative thoughts (also) leading to the detection of fewer lights. Visual search data may shed more light on the precise changes that occur under anxiety in visually attending to specific locations on the climbing wall (cf. Murray & Janelle, 2003; Williams & Elliott, 1999).

GENERAL DISCUSSION

J.J. Gibson (1979/1986) suggested that the environment is perceived in actor-relevant terms, that is, in terms of what an actor can do with and in the environment. In keeping with this notion, research has shown that changes in one's potential to act influence the perception of action possibilities (e.g., Bhalla & Proffitt, 1999; Pijpers et al., in press; Proffitt et al., 1995). Based on that idea, we assumed that changes in the actor's emotional state that lead to changes in his or her action capabilities will also lead to changes in the perception of those action possibilities. Perception–action experiments on a climbing wall allowed us to investigate the influence of the actor's emotional state—anxiety—on perceiving and realizing affordances.

Experiment 1 demonstrated that anxiety reduced both perceived and actual maximal reaching height. Subsequently, in Experiment 2 and in line with the results of Experiment 1, anxiety was found to affect the realization of action possibilities, leading to the use of more holds on the same traverse. Experiment 3 particularly provided support for attentional narrowing as an additional underlying mechanism (on top of the reduction of perceived and actual maximal reaching height) of the anxiety-induced changes in realizing affordances, as found in Experiment 2. Note that grasping holds that are easily within reach rather than at the maximum of one's reachability is consistent with attentional narrowing. If attention narrows, one is bound to grasp those holds that are closer and still within one's field of attention. Of course, these results do not discard the possibility that, in Experiment 2, the use of more holds reflects a more conservative and safer climbing strategy independent of attentional narrowing.

The findings of Experiments 1 and 3 indicate that anxiety affects the detection of information about the action possibilities in the environment, whereas the findings of Experiment 2 (and Experiment 1) suggest that anxiety constrains the realization of action possibilities. In our view, these findings suggest how, from an ecological point of view, the perception and realization of affordances might be understood in situations in which emotional processes are in play.

As an entry point to discussing the theoretical implications, it is useful to first turn to the results of Jiang and colleagues (Jiang & Mark, 1994; Jiang, Mark, Anderson, & Domm, 1993) on the perception of gap crossability. They found that, when individuals had to judge whether they could step over a gap, their estimates of crossable gap width decreased as gap depth increased. This finding seems to refer to a process similar to that addressed in this study in that increased gap depth led to increased anxiety, which in turn affected the perception of gap crossing capability. However, Jiang and colleagues disputed that emotional processes were causing the more conservative assessments. They attempted to substantiate this claim by showing that estimates of gap crossing capability critically depended on where observers directed their gaze. When looking down into the gap, participants tended to underestimate their capabilities more than when they looked toward the horizon. This explanation, however, does not preclude the possibility that gaze direction and emotional processes covaried (cf. Janelle et al., 1999; Murray & Janelle, 2003; Williams & Elliott, 1999; Williams, Vickers, & Rodrigues, 2002), that is, when participants looked down into the gap, they may have felt some fear of the depth resulting from the increased risk to their safety. When they looked at the horizon, participants may have felt no fear or less fear. Hence, anxiety might have played a role in the observed changes in the perception of gap crossability.

In line with previous findings (e.g., Bhalla & Proffitt, 1999; Proffitt et al., 1995), we once more found support for the intricate relation between the perception and the realization of action possibilities. An observer who is in a threatening environment will pick up information about that environment as well as information about his or her own (emotional) state. The latter will deviate from ordinary feelings, sensations, and so forth, and the observer will behave accordingly. As such, the anxiety-induced bodily and physiological reactions are part and parcel of the properties of the animal–environment system in which affordances are perceived and realized. Many studies have reported all kinds of bodily changes under threatening conditions (e.g., Brooke & Long, 1987; Frijda, 1986; Weinberg & Hunt, 1976). Given the mutuality of observer and environment, it follows that changes in action capabilities will be detected, which will affect the individual's perception of affordances. Using a similar setup to that used in this study, Pijpers et al. (2003) demonstrated considerable and significant increases in blood lactate concentration and muscle fatigue under anxiety. Evidently, the environment affected the neuromuscular system and participants accounted for these effects when asked to judge their maximal reaching height in that environment. Hence, anxiety-induced changes in action capabilities closely corresponded to changes in the perception and realization of affordances.

In conclusion, an actor's emotional state affects the perception and realization of affordances in a manner that is consistent with the changes that accompany this emotional state, such as changes in attention and actual action capabilities. Rather than portraying this emotional state as a spooky and subjective variable, this once more emphasizes the intricate relations between actor and environment and perception and action.

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